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GEOSPATIAL ANALYSIS OF THE IMPACTS OF JIBIA DAM IN NIGERIA ON ITS SURROUNDING ENVIRONMENT

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Abstract
The impact of Jibia dam was assessed in relation to changes in land cover from 1986 to 2016. No previous work has covered such period in such extensive way using remote sensing method. Satellite images of 1986, 1990, 2003 and 2016 were acquired and classified into: Settlement, Jibia Irrigation Site, Water body, Forest, Farm land and Bare land. Jibia landscape is dominated by Farmland and bare land that covered over 92% before the dam construction, but reduced to 77%. The major changes occurred between the two dominate land use land cover classes (LULC). The creation of the dam and hence the Jibia Irrigation site accounted for 10% (3472 ha) of study area. Forestry presented a marginal decrease approximating but inverse of the settlement. The rate of change of LULC were marginal (less than 1%).The construction of the dam on farming activities remained between 51 to 65% with highest in 1990 (immediately after the construction), but after, it fell below the area of farming land before the dam.

Keywords: Land use, land cover, image classification, rate of change in LULC

1. Introduction

Dams are created to have socio-economic impact on the lives of the people living closer to the in its environment (FMWR, 2014, Yusuf and Yusuf, 2013, Musa *et. al.*, 2013). The impact of dams has been studied extensively and generally (Zhao et al., 2010, WCD, 2000, Dalil *et al.*, 2013*;* Dukiya, 2015, Zemba *et al.*, 2016). However, each dam has its peculiarity - different local conditions and influence, and land use. Thus, there is need to continue such study and particularly where such studies were not done intensively before, such as the Jibia Dam.

The impact of dams can be reflected in the ways the land is being put to use and in what covers the land. Studies of land use land cover (LULC) in relation to the creation of dams has been carried out severally in historical and predictive ways (Zhao *et al.*, 2010 and Zhao *et al.*, 2012). Studies such as Rawat and Manish (2015) and Kellogg and Zhou (2014) provided both methodology and example of the application of remote sensing in such study.

A Google Scholar search of "Jibia Dam" brought up 20 articles. The ones that directly study the dam (and not merely mentioned it) are grouped as follows: Engineering (Sembenelli, 1990, Srivastava and Sivakumar Babu, 2013); Project Development (Sonuga *et al.*, 2002); Agricultural and aquaculture, economy (Musa *et al.*, 2013, Musa *et al.*, 2015); Remote Sensing and GIS (Funtua *et al.*, 2015).

Funtua *et al.* (2015) conducted an analysis of LULC in the neighbourhood of the Jibia dam using Landsat satellite images of 1986, 1990 and 2010. The 1986 image was before the construction of the dam, the image of 1990 was captured immediately after the construction, and the 2010 provide the state of land cover some ten years after. However, it is now over seven years, which is possible, that changes in the land cover had occurred. Therefore, a current image was sought and classified. Rather than simply classifying the current image, previous images were also classified more rigorously. Changes in land cover from one epoch to another were then analysed. Furthermore, the rates at which the changes were occurring were computed.

Jibia Dam was constructed about thirty years ago, for irrigation and domestic water supply. There are very few records of the details of environmental situation prior to and after the construction of the dam. The data captured by satellite of an area were of general nature with no bias per se, this is unlike when people bring in their bias in historical retrievals. This method will answer quantitatively the distribution of land use before the creation of the dam; what they are immediately after and what they are in the long run. This paper reports the work which analysed the impacts of Jibia dam on LULC changes in the area by: (1) LULC was mapped prior to and after the construction of the dam; (2) the determination and analysis of rate at which the changes of the LULC classes were conducted.

2. Materials and method

2.1 Location of Study

Jibia Dam is located in Jibia L.G.A., town in Katsina State, Nigeria, very close to the boarder of Nigeria and Niger Republic (Figure 1). It was constructed on a Gada River in the 1980s. The Dam is 3680m length, 21.5m high, 9.50m crescent length, 1.3m and 1.25m up and down the width of the downstream. The dam can create 1.2m/s pressure at the base of the dam. The primary purpose of constructing Jibia Dam was to impound water for irrigation farming and domestic needs. The project consists of two-surface Reservoir of 35000m^3 and 45000m^3 for supplying irrigation water to a network of 192km irrigation Canals for distribution of water to 3500 Hectares of farmland. It also consists of 12,000m^3 capacity treatment plant constructed to supply domestic water (SRRBDA, 1989).

2.2 Data

Table 1 provides the list of the Landsat images used, downloaded from the United States Geological Survey (USGS, 2016). The images are cloud-free data, near the same date of acquisition and in the same climatic season (to reduce the effect of seasonal difference on the images).

Table 1: Description of Remote sensing data

Platform (sensor)	Row/Column	Data Acquired	Spatial Resolution
Landsat 4	189/51	08/01/86	30m
Landsat 5	189/51	12/02/90	30m
Landsat 7	189/51	1/1/03	30m
Landsat 8	189/51	11/1/16	30m

2.3 Software and Device

A handheld GPS receiver Garmin 75x was used for capturing the position of the distinct location on both of the images and map and for navigation in the study area during ground truthing. Erdas Imagine version 2014 was used for image pre-and-post processing analysis (Lillesand *et al.,* 2008, Garba and Brewer, 2010) and ArcGIS version 10.4.1 was used for the mapping and analysis (Garba and Brewer, 2010).

2.4 LULC Classification

Land cover classification of the satellite images was based on the reflectance of the features on the earth surface.Six LULC classes were used in the classification and analysis. These are: (i)

Settlement, (ii) Forest, (iii) Farmland, (iv) Water Body, (v) Bare Soil and (vi) Irrigation site (due to construction of the dam and peculiar to the Jibia).

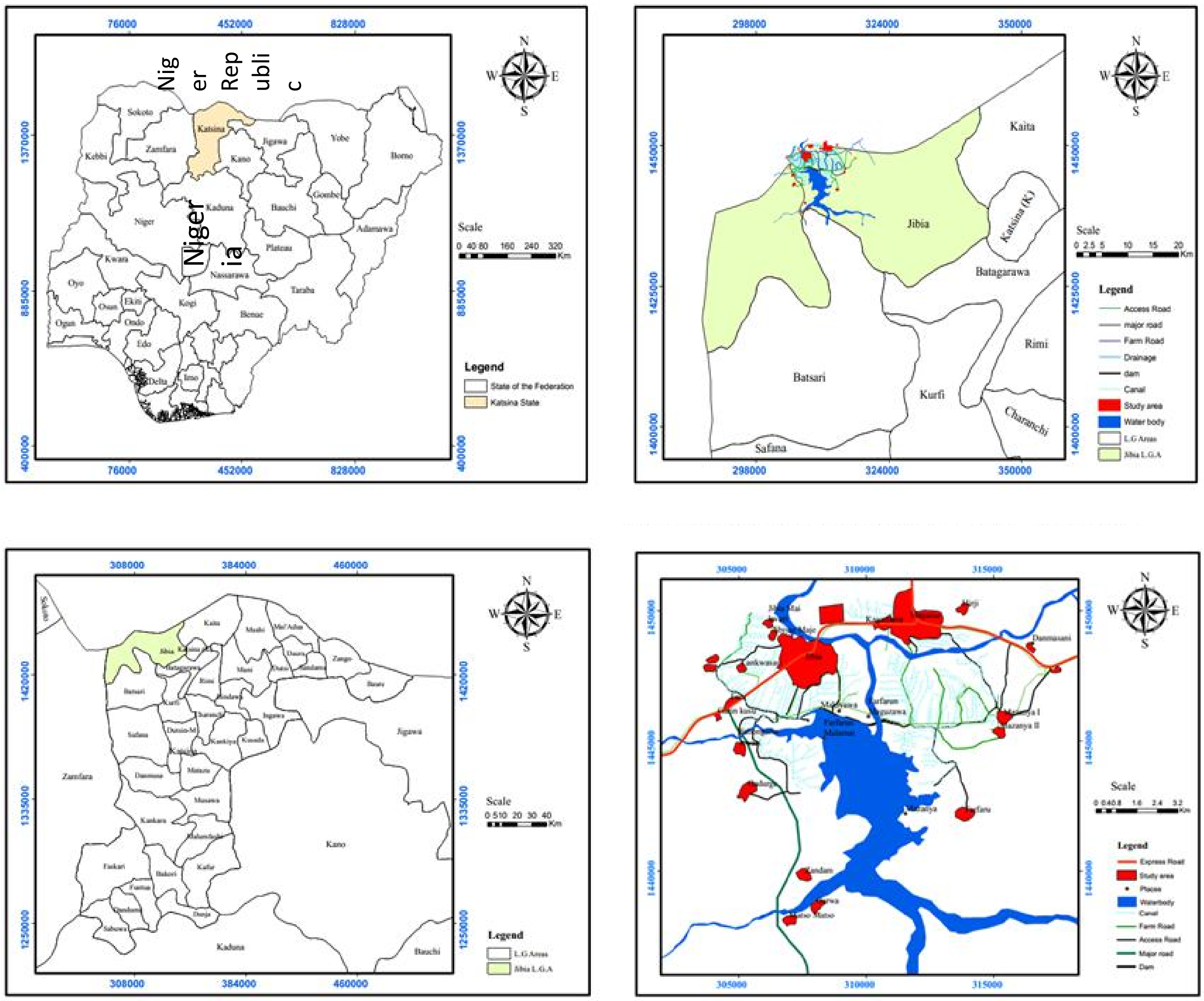

Figure 1: Jibia town (lower right) is in in Jibia local government (upper right) of Katsina state (lower left) which on the border with Niger Republic (upper left)

2.4.1 Classification

A supervised classification was conducted (Lillesand *et al.,* 2008, Garba and Brewer, 2010). The coordinates of locations where samples of different LULC classes were generated from high-resolution Google Map for training sample and after, for the image classification assessment. Training data were also vetted by ground Truthing, which was the matching of cluster of a pixels and the actual LULC categories. The training areas were delineated, and the frequency of all spectral bands examined to ascertain a homogenous training data and to assess the usefulness of the selected training data. The objective of the training set is to enable the classification algorithm learn and conduct classification.

During the field survey, 16 Ground Control Points (GCP) were also collected using the GPS instrument, across the study using visible and definite shaped object on the satellite image (Garba and Brewer, 2010 and Garba et.al., 2018), for the purposes of geometric correction . These GCPs were captured from distinct features on the ground and images such as road junctions, buildings, and much other landscape feature identifiable clearly on the satellite images. The points were used to minimise geometric distortions in the images by georeferencing. This was also used to unify the coordinate system of the satellite images for the spatiotemporal analysis.

Maximum likelihood classification was used in classifying LULC classes. To determine the level of classification accuracy, post-classification accuracy assessment and filtering was performed which provided clear and homogenous information categories. Post classification comparison was carried out to analyse the changes in LULC of the area (Lillesand *et al.,* 2008, Garba and Brewer, 2010).

2.5 Determination of the Rate of expansion

The rate of change in a particular land cover was determined by the difference in area between two time periods, dividing it by the duration (Eqn 1).

$$Ca = \frac{LCLU_a(t2) - LCLU_a(t1)}{t2 - t1} \qquad (1)$$

Ca = The rate of change in area for a particular LULC
$t1, t2$ = time 1, time 2

3. Results and Discussion

3.1 Impact of Jibia dam on LULC changes (1986-2016)

The classification produced the LULC map for 1986, 1990, 2003 and 2016 with accuracies of 84%, 86%, 79% and 78% respectively. The classified images are for 1990, 2003 and 2016 are in Figures 2 and 3 respectively.

The area covered by each of the LULC classes are given Table 2 in percentage. Farmland and bare ground dominated the landscape throughout the period of studies. It accounted for over 90% before the creation of the Dam and remained over 77% after the construction. Then the Jibia irrigation site accounted for 10%, and fairly remained the same throughout the period of the study. These three land uses therefore accounted for about 90% of the land scape. There was approximately equal inter-change between Farmland (-14%) and Bare land (12%) between 1990 and 2003, however the change reversed between 2003 and 2016 (farm land 4% and bare land -5%).Thus after the initial conversion of farmland and bare land by 1990 to basic Irrigation site,

the major changes continued mainly between the two. The construction of the dam on farming activities (farm land and jibia irrigation site) remained between 51 to 65%, with the highest in 1990 immediately after the construction, but after it fell below the area of farming land before the dam construction. Water body first increased from about 4% to about 9% and remained so from 2003 and 2016. Therefore, there seems to be other factors affecting the its size apart from the first impact of the dam.

Table 2 also shows that there were marginal increment in settlement (between 1 to 3% of the study area), and forestry reduced from about 3% to less 1%. It tends to show an inverse relationship between the two, although the changes are marginal and can be accounted by other factors.

Table 2: Percentage of LULC classes in the study area.

LULC Classes	1986 (%)	1990 (%)	2003 (%)	2016 (%)	1886 - 1990	1990 - 2003	2003 - 2016
Settlement	1.11	1.2	1.80	2.73	0.09	0.6	0.93
Jibia Irrigation Site	0.00	10.4	10.36	10.36	10.4	-0.04	0
Water body	3.62	7.3	9.20	8.97	3.68	1.9	-0.23
Forest	2.56	2.4	1.34	0.83	-0.16	-1.06	-0.51
Farm land	59.64	54.7	41.18	45.62	-4.94	-13.52	4.44
Bare land	33.08	24.0	36.13	31.47	-9.08	12.13	-4.66
Total	100	100	100	100			

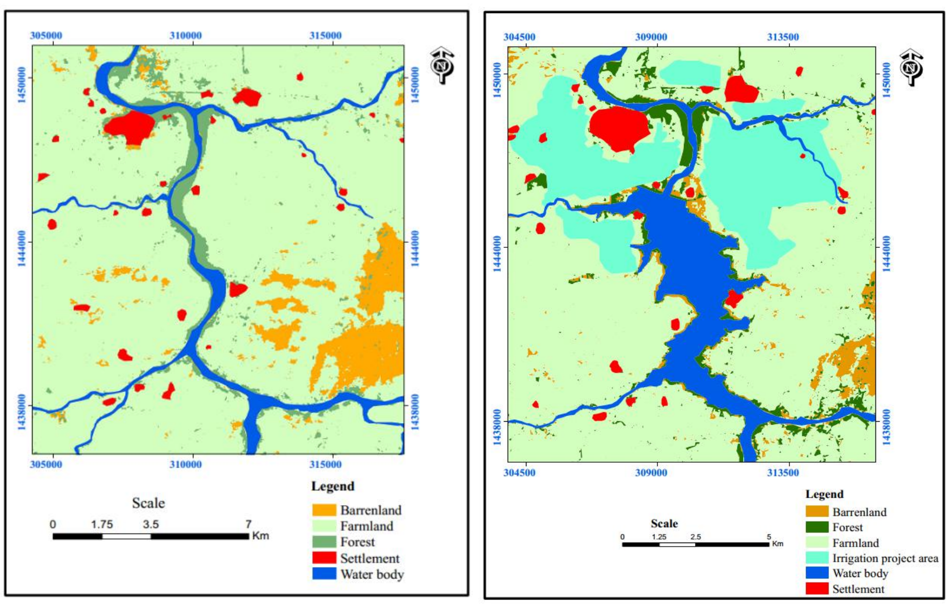

Figure 2 (a) 1986 Classified LULC, (b) 1990 classified LULC

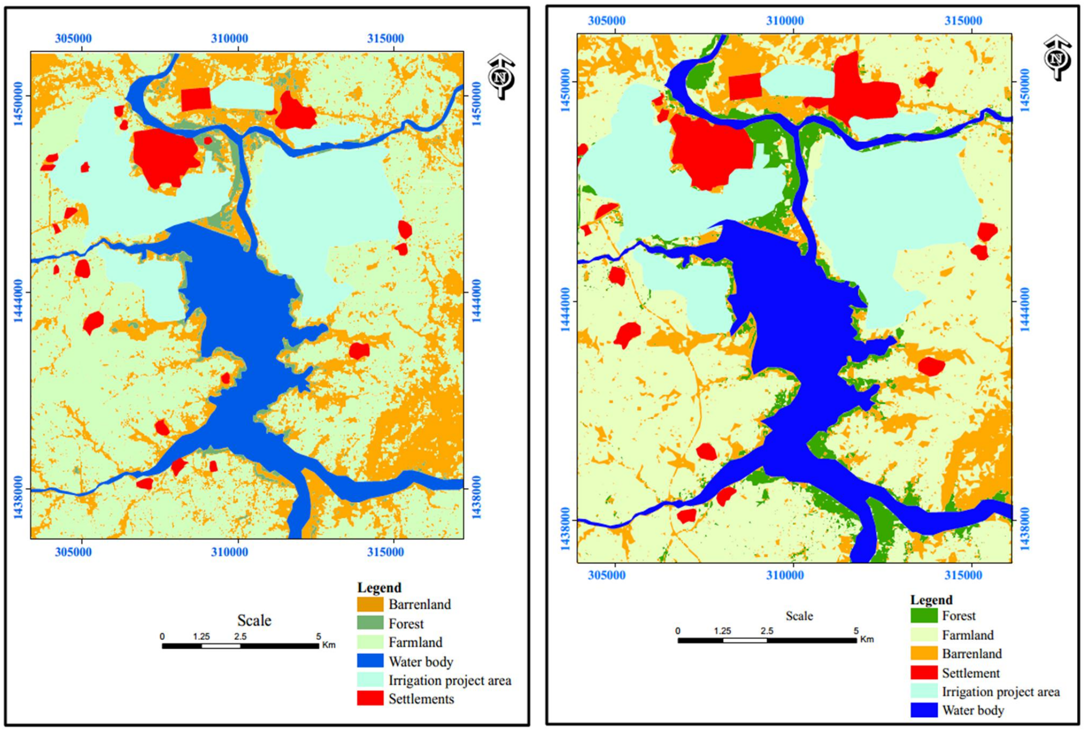

Figure 3 (a) 2003 Classified LULC, (b) 2016 classified LULC

3.2 Analysis of the rate of LULC changes in the study area

The rate of changes of all the types of LULC in the area were marginal (less 3% with most less than 1%, Table 3). The irrigation site had the highest rate of 3% (actually, 10% but divided by the period, 1986 -1990), because the construction of the dam. However, it did not grow after 1990. Settlement continues to increase in its rate of growth (although very small, less than 0.1%). This indicates a geometric rise in population). In the case of water, there was a major increase, followed by a small rate (0.15%) and failed to grow (tending to negative very small rate after 2003).The rate losses and gains in Forest and farmlands are similar but reverse, except for the years that followed the construction of the dam are higher than any other except.

Table 3: The rate of Changes of LULC

LULC	Period 1986 - 1990 %	1990 - 2003 %	2003 -2016 %
Settlement	0.02	0.05	0.07
Jibia Irrigation Site	2.60	0.00	0.00
Water body	-1.04	0.15	-0.02
Forest	0.93	-0.08	-0.04
Farmland	-1.24		0.34
Bare ground	-2.27		-0.36

4. Conclusion and recommendation

The construction of the Jibia dams had direct and major impact on farm land and bare land. The dam created the Jibia Irrigation site which took 10% (3472ha) of study area. Forestry presented a marginal decrease approximating an inverse of the settlement. When the rates of changes were computed they were all small, less than 3%, and mainly related to farmland and bare land. Changes in land use continued after the initial impact of the dam creation. Only settlement and forestry have shown consistency in trend. However, farm land and bare have shown that there are other factors at work other than the initial losses by both.

Although the relative size of settlement and forestry in relation to other land uses is small (each less than 3%, Table 2), there seem to be some relationship between them. Hence, it is recommended that the two be isolated for further study, which would include population and distances between them.

Secondly, it is recommended that there is need to investigate the causes of the changes and the means of reversing the changes between bare land and farmland.

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